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Responses of gas exchange and plant hydraulic conductance to water deficit in silver birch trees growing under increasing atmospheric humidity

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Climate change scenarios predict increase in air temperature by 3.5–5˚C and precipitation by 5–30% in boreal and northern temperate regions of Europe by the end of the century. On the other hand, climate extremes including heat waves and droughts are projected to become more frequent and last longer across Europe over the 21st century. Increasing atmospheric humidity inevitably occurring with more frequent rainfall events reduce water fluxes through the vegetation, and have an effect on the structure of leaves and vascular tissues, plant hydraulic properties, biomass allocation, nutrient uptake and growth (Tullus et al. 2012). We investigated fast and long-term effects of water deficit on plant water status, gas exchange and hydraulic conductance on saplings of silver birch (*Betula pendula*) growing under artificially manipulated air humidity in an experimental forest ecosystem at the Free Air Humidity Manipulation site (http://www.lote.ut.ee/FAHM/in-english; Kupper et al. 2011). Fast-developing water deficit was imposed by letting cut sample branches to dehydrate in open-air conditions, long-term water deficit was generated by seasonal drought. The fast-imposed water deficit estimated by leaf (Ψ_L) or branch water status (Ψ_B) had highly significant (P <0.001) effect on all studied parameters, while inclusion of Ψ_B in ANCOVA models resulted considerably better approximation as compared to Ψ_L. Thus, leaf gas exchange and hydraulic capacity primarily depend on potential water supply rather than on current leaf water status. Under moderate water deficit leaf conductance to water vapour (g_L), transpiration rate (E) and leaf hydraulic conductance (K_L) were significantly (P <0.05) higher and leaf temperature (T_L) lower in trees grown at elevated air humidity (**H** treatment) as compared to control trees (**C** treatment). Under severe water deficit the differences between the treatments disappeared. The humidification manipulation influenced most of the studied characteristics, while the effect realized primarily through changes in soil water availability, i.e. due to higher soil water potential in **H** treatment. Two functional characteristics - $g_L$and K_L – demonstrated significantly (P <0.05) steeper decline with increasing water deficit in **H** treatment if compared to **C**, indicating higher susceptibility to weather fluctuations of trees grown in humid atmosphere. It means greater risk of xylem cavitation and possible hydraulic dysfunction under conditions of weather extremes. Shifts in plant hydraulic traits were co-ordinated with those in both stomatal conductance (g_S) and net photosynthesis (A_n), while the strongest relationships were observed with whole-tree conductance (K_T; R^2=0.80-0.85, P <0.001). Inverse relationship between hydraulic characteristics and photosynthetic water-use efficiency implies a trade-off between water transport and use efficiencies both at the leaf and whole-plant scales.

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